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From the Editors

This issue of *The Victorian Naturalist* offers variety in focus, including both terrestrial and aquatic vertebrates, as well as a paper on flora. In addition, two of these articles take in historical aspects of their subjects. To this extent, the issue might be seen as exemplifying one of the strengths of this journal — its preparedness to cross disciplinary boundaries where appropriate. Such inclusiveness has long been a feature of the journal, and one which is encouraged by its editors.

The Editors offer their sincere apologies to Ed Grey, long time FNCV member and former Editor of this journal, for inadvertently changing his name, in the Table of Contents of the June 2012 issue.

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Front cover: Common Blue-tongued Lizard. (See p. 128). Photo by Peter Homan.
Back cover: The Separation Tree, Royal Botanic Gardens, as viewed from the north (June 2011). (See p. 147) Photo by Peter Fagg.

The use of artificial habitat during surveys of small, terrestrial vertebrates at three sites in Victoria

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Abstract

Artificial refuges can be used to determine the presence of terrestrial fauna and to replace or enhance lost or degraded natural habitat. Concrete pavers, roof tiles, sheets of galvanised iron and old fence posts were used at three sites in southern and western Victoria to determine the presence of small terrestrial vertebrates and to provide artificial habitat. Twenty species were recorded comprising two mammals, 12 reptiles and six amphibians. Fat-tailed Dunnart *Sminthopsis crassicaudata* was recorded on eight occasions using roof tiles in a lightly grazed, grassland site on the Victorian Volcanic Plain. Growling Grass Frog *Litoria raniformis* was found under old fence posts beside a restored wetland. Little Whip Snake *Parasuta flagellum* was recorded under artificial refuges from areas with thick grass or tussock cover. Spotted Marsh Frog *Limnodynastes tasmaniensis* was found in large numbers under all forms of artificial habitat. Concrete pavers and old fence posts returned the highest diversity of species and the greatest number of individuals. The usefulness of artificial terrestrial habitat as a survey method is compared with other survey methods. The value of artificial habitat as a management tool and associated problems are discussed. (*The Victorian Naturalist* **129** (4) 2012, 128–137)

Keywords: artificial habitat, Fat-tailed Dunnart, Growling Grass Frog, Little Whip Snake, skinks, frogs

Introduction

Natural terrestrial structures, such as surface rocks and fallen logs, provide important habitat for a wide range of vertebrate and invertebrate fauna (Menkhorst 1995; Cogger 2000; Ballinger and Yen 2002; Banks and Bennett 2003; Wilson and Swan 2010; Lindenmayer *et al.* 2011). However, in many parts of south-eastern Australia, such habitat has been removed or severely degraded. Mac Nally *et al.* (2002) estimated that levels of fallen wood on the southern Murray-Darling Basin may be approximately 15% of pre-European settlement levels. In Victoria, the loss of coarse woody debris from forests and woodlands is listed as a potentially threatening process under the *Flora and Fauna Guarantee Act 1988* (DSE 2009). In many districts, on both private and crown land, fallen limbs and logs have been harvested for firewood. In New South Wales, firewood cutting is listed as a key threatening process in temperate woodlands under the *Threatened Species Conservation Act 1995*. During control burning exercises designed to reduce natural fuel loads in forests and woodlands, fallen logs have often been split and allowed to burn.

During the early days of European settlement surface rock was commonly used in many districts to construct dry stone fences and other structures. In recent times rocks have been harvested from the Victorian Volcanic Plain to be used in landscaping of suburban gardens. In south-east New South Wales removal of sandstone boulders for construction of bush gardens has been a major threatening process to rare fauna (Shine 1991). Shine *et al.* (1998) identified several species of herpetofauna that are likely to be at risk from removal of bush rocks. Similar habitat degradation has occurred in other parts of the world. In the western United States of America, illegal wildlife collecting has resulted in severe and widespread damage to reptile habitat in desert rocky outcrops (Goode *et al.* 2005). At sites where natural terrestrial habitat has been altered or destroyed, a range of artificial materials can be used as a survey method to determine the presence of small vertebrates and as a management tool to replace or enhance degraded environments. This paper examines the use of four types of artificial terrestrial material, as survey methods and in habitat enhancement programs, during long-term studies at three sites in southern and western Victoria. The artificial material comprised standard roof tiles, pieces of galvanised iron, old fence posts and four types of concrete pavers.

Study sites

Challicum is a 1300 ha sheep grazing property approximately 170 km west of Melbourne on the Victorian Volcanic Plain (37° 24'S, 143° 08'E). The land owner joined Land for Wildlife, the Victorian Government's voluntary conservation scheme, in 1990. Since then, various conservation works have been undertaken including fencing-off native grasslands and woodland areas, revegetation works and restoration of an ephemeral wetland (Homan 2011). A long-term study of the vertebrate fauna of the property commenced in December 2002 (Homan 2004). The survey sites at Challicum were located in the Ecological Vegetation Class (EVC) Plains Grassy Woodland.

Quarry Hills Bushland Park (QHBP) is situated in the suburb of South Morang approximately 22 km north-north-east of the Melbourne CBD. The park comprises two elevated sections: a western section known as Quarry Hill (EVC: Grassy Dry Forest, degraded) (37° 37'S, 145° 03'E) and an eastern section known as Granite Hills (EVC: Granitic Hills Woodland, degraded) (37° 37'S, 145° 05'E). The two sections are separated by an extensive housing estate. Major conservation works have been undertaken including weed removal, revegetation, rabbit control and a habitat enhancement program.

The Growling Frog Golf Course (GFGC) is located in Yan Yean, approximately 33 km north-north-east of the Melbourne CBD (37° 33'S, 145° 04'E). The golf course was developed under strict environmental guidelines that required the protection of native vegetation and important habitat. Major conservation works have been undertaken including construction of permanent wetlands for the Growling Grass Frog *Litoria raniformis*, rabbit control, weed removal, revegetation and a habitat enhancement program. The EVC for survey sites at GFGC was Plains Grassy Woodland, degraded.

QHBP and GFGC are both managed by the City of Whittlesea. Surveys to assess conservation works and to determine the presence and relative abundance of vertebrate fauna have been conducted at both reserves since 2006 and 2007 respectively (Homan unpubl.data).

Methods

Challicum

Standard roof tiles (410 x 245 mm), old fence posts (1200–1500 x 180–230 mm) and galvanised iron (Average: 600 x 600 mm) were used in several parts of this property (Table 1). Survey sites included areas of fenced-off Plains Grassy Woodland, ephemeral wetlands and areas with native grasses, fallen logs, surface rocks and cracking, unploughed soils. A 64 ha paddock with large expanses of native grasses, several ephemeral wetlands and some fallen logs and stumps was chosen as a principal survey site. This paddock had never been ploughed and was only lightly grazed. It also contained many mature River Red Gums *Eucalyptus camaldulensis*. Four grids of 25 roof tiles per grid were laid between December 2003 and June 2004. One grid was in a section of the paddock with a thick cover of Wallaby Grass *Austrodanthonia* sp. and Spear Grass *Austrostipa* sp., near an ephemeral wetland. Six old fence posts and five pieces of galvanised iron were alternated 10 m apart around this wetland. Three other tile grids, 50 m apart, were established in open sections of this paddock in areas of sparse cover of Wallaby Grass with some introduced pasture. Each tile grid contained five lines, with five tiles on each line. Lines and tiles were spaced at 5 m within each grid.

In August 2005, another grid of 25 roof tiles (configuration as above) was established in a recently fenced-off area of Plains Grassy Woodland in another part of this property. At the same time 14 old fence posts and 22 pieces of galvanised iron were placed alternately in a line in this area. Posts and galvanised iron were 10 m apart. In May 2006, 43 old fence posts (Fig. 1) were placed 10 m apart around the edges of two ephemeral wetlands in other parts of the property. Artificial habitat at Challicum was monitored on 19 occasions, once every three months between June 2004 and November 2007 and once in November 2009, November 2010, April 2011 and September 2011. Each type of habitat was checked early in the morning on each occasion, usually within two hours of day-break.

Artificial habitat used at QHBP and GFGC was sourced opportunistically as various items

Table 1. Number of each type of artificial habitat used at Challicum, Quarry Hills Bushland Park (QHBP) and Growling Frog Golf Course (GFGC).

	Roof Tile	Galvanised Iron	Fence Post	Concrete Paver
Challicum	125	27	63	
QHBP	50	35		100
GFGC		22		68

became available during demolition of several local properties. As a consequence galvanised iron used at these two sites was a different size from that used at Challicum. Rather than send this material to landfill it was decided to use these items as part of habitat enhancement programs at these two sites.

Quarry Hills Bushland Park

Standard roof tiles, galvanised iron (Average: 800 x 800 mm) and concrete pavers (380 x 380 x 45 mm) were used at this site (Table 1). In March 2006, five lines of roof tiles, with 10 tiles spaced every 10 m on each line, were established in grassland areas in the western section of this reserve. The sites contained Weeping Grass *Microlaena stipoides*, some Spear Grass *Austrostipa* sp., small areas of *Lomandra* sp and introduced grasses. Lines of tiles were approximately 100 m apart. At the same time, in the woodland area on the eastern side of the reserve, five lines of concrete pavers (Fig. 2) with 10 pavers 10 m apart on each line, were established. Lines were approximately 50 m apart and a nesting chamber with an entrance hole was excavated under each paver. Also at this time one line of 35 pieces of galvanised iron 10 m apart was established in this area. By December 2006, many roof tiles had sustained damage and disturbance, therefore two lines were replaced with concrete pavers. In March 2009, the remaining 30 roof tiles were replaced with concrete pavers. Because of human interference the line of galvanised iron was removed in February 2008. Artificial habitat at QHBP was monitored on 10 occasions, once every six months between September 2006 and May 2011.

Fig. 1. Old fence posts beside restored ephemeral wetland at Challicum. Photo by Peter Homan.

Growling Frog Golf Course

Galvanised iron (Average: 800 x 800 mm) and concrete pavers of three shapes and sizes (600 x 600 x 50 mm; 600 x 135 x 50 mm; 880 x 165 x 50 mm) were used at this property (Table 1). In March 2008, 22 concrete pavers and 22 pieces of galvanised iron were laid alternately 10 m apart in a line amongst introduced grasses in degraded Plains Grassy Woodland on the eastern side of this property. At the same time an additional 16 pavers were laid 10 m apart in a line adjacent to a dry stone fence on the western boundary of the property. In February 2010, an additional 30 concrete pavers were laid 10 m apart in a line on the eastern side, south of the original line mentioned above. A nesting chamber with an entrance hole was excavated under each paver.

Fig. 2. Concrete paver at Quarry Hills Bushland Park. Photo by Peter Homan.

Fig. 3. Fat-tailed Dunnart *Sminthopsis crassicaudata*. Photo by Maryrose Morgan.

Artificial habitat at GFGC was monitored on six occasions, once every six months between September 2008 and May 2011.

Results

Twenty vertebrate species were recorded using artificial terrestrial habitat (Table 2). These included two mammals: the Fat-tailed Dunnart *Sminthopsis crassicaudata* (Fig. 3) was recorded beneath roof tiles on eight occasions and a fence post on one occasion at Challicum; the introduced House Mouse *Mus musculus* was found under roof tiles, fence posts and galvanised iron at Challicum. This species was also found under concrete pavers, galvanised iron and a roof tile at GFGC and QHBP.

Twelve species of reptiles, comprising eight skinks and four elapid snakes, were recorded (Table 2). Southern Grass Skink *Pseudemoia entrecasteauxii*, Tussock Skink *Pseudemoia pagenstecheri* and Blotched Blue-tongued Lizard *Tiliqua nigrolutea* were recorded under galvanised iron at Challicum. Common Blue-tongued Lizard *Tiliqua scincoides* (Front cover) was found under all forms of artificial refuges at Challicum. The Tussock Skink was also found under roof tiles and an old fence post at this site. Eastern Three-lined Skink *Acritoscincus duperreyi*, Large Striped Skink *Ctenotus robustus* (Fig. 4), Garden Skink *Lampropholis guichenoti*, Bougainville's Skink *Lerista bougainvillii* and Common Blue-tongued Lizard were all recorded at QHBP. At GFGC, Tussock Skink, Bougainville's Skink, Large Striped Skink and Common Blue-tongued Lizard were recorded. A Tiger Snake *Notechis scutatus* was recorded under an old

Fig. 4. Large Striped Skink *Ctenotus robustus*. Photo by Tim Connell.

fence post beside an ephemeral wetland and under galvanised iron in grassland at Challicum. One sub-adult Eastern Brown Snake *Pseudonaja textilis* was recorded under a roof tile on this property. An Eastern Brown Snake was recorded under a large paver at the GFGC. Lowland Copperhead *Austrelaps superbus* was recorded under pavers and galvanised iron at QHBP and under pavers at GFGC. Little Whip Snake *Parasuta flagellum* (Fig. 5) was recorded under all forms of artificial habitat at all three study sites.

Six species of amphibians, comprising two hylid frogs and four myobatrachid frogs, were recorded (Table 2). The majority of records of amphibians at Challicum were from refuges placed near ephemeral wetlands. Growling Grass Frog *Litoria raniformis* (Fig. 6) was found on two occasions under old fence posts beside a restored ephemeral wetland on this property.

Table 2. List of vertebrate species and numbers recorded using artificial habitat at Chalicum, Quarry Hills Bushland Park (QHBP) and Growling Frog Golf Course (GFGC). RT = Roof Tile; GI = Galvanised Iron; FP = Fence Post; CP = Concrete Paver. * indicates introduced species.

Species	Challicum			QHBP			GFGC	
	RT	GI	FP	RT	GI	CP	GI	CP
Fat-tailed Dunnart *Sminthopsis crassicaudata*	8		1					
House Mouse *Mus musculus* *	3	15	10	1		3	1	6
Eastern Three-lined Skink *Acritoscincus duperreyi*					4	1		
Large Striped Skink *Ctenotus robustus*						4		1
Garden Skink *Lampropholis guichenoti*				1	1			
Bougainville's Skink *Lerista bougainvillii*						2	1	5
Southern Grass Skink *Pseudemoia entrecasteauxii*		7						
Tussock Skink *Pseudemoia pagenstecheri*			5				4	
Blotched Blue-tongued Lizard *Tiliqua nigrolutea*		1						
Common Blue-tongued Lizard *Tiliqua scincoides*	2	3	1	5	4	26	3	2
Lowland Copperhead *Austrelaps superbus*					1	2		4
Tiger Snake *Notechis scutatus*		1	1					
Little Whip Snake *Parasuta flagellum*	15	8	7	1	1	13	1	1
Eastern Brown Snake *Pseudonaja textilis*	1							1
Growling Grass Frog *Litoria raniformis*			2					
Southern Brown Tree Frog *Litoria ewingii*	1	1	16					
Plains Froglet *Crinia paransignifera*			1					
Common Froglet *Crinia signifera*	1		11			2		
Southern Bullfrog *Limnodynastes dumerilii*						12	1	
Spotted Marsh Frog *Limnodynastes tasmaniensis*	65	24	27	3		33	12	71

Significant numbers of Southern Brown Tree Frog *Litoria ewingii*, Common Froglet *Crinia signifera* and Spotted Marsh Frog *Limnodynastes tasmaniensis* were found under fence posts beside ephemeral wetlands at Challicum. One Plains Froglet *Crinia paransignifera* was found under a fence post beside an ephemeral wetland on this property. Common Froglet and Spotted Marsh Frog were also located under roof tiles in grassland areas at Challicum. Spotted Marsh Frog was located in significant numbers under all forms of artificial habitat at QHBP and GFGC. Many Southern Bullfrogs *Limnodynastes dumerilii* were found under concrete pavers at QHBP.

Discussion

Fat-tailed Dunnart

The Fat-tailed Dunnart is nocturnal and uses natural structures such as rocks and fallen logs for nesting sites and shelter during the day (Menkhorst 1995). The species also shelters under artificial refuges and has been recorded in western Victoria under discarded fence posts and abandoned farm implements (Bennett 1982).

Fat-tailed Dunnarts were recorded at Challicum only under roof tiles from grids established in areas with sparse ground cover. The only other survey method used in the vicinity of these grids was systematic searching under fallen logs and old stumps, which resulted in the capture of one specimen. One other Fat-tailed Dunnart was found under an old fence post positioned beside a restored wetland surrounded by a large expanse of heavily grazed introduced pasture. No Fat-tailed Dunnarts or evidence of the species (scats) were found under artificial habitat of any sort in areas with thick ground cover. Two pitfall lines were established at Challicum, but both were in areas with thick tussock cover, and neither recorded Fat-tailed Dunnart. Morton (1978), Read (1984), Hadden (2002) and Parker (2009) also found that Fat-tailed Dunnart preferred areas with sparse ground cover.

Live-trapping, using wire cage traps of various designs, and Elliott traps (Elliott Scientific Equipment, Upwey, Victoria), has been used extensively to survey terrestrial mammals in Victoria, including small dasyurid marsupi-

Fig. 5. Little Whip Snake *Parasuta flagellum*. Photo by Peter Homan.

Fig. 6. Growling Grass Frog *Litoria raniformis*. Photo by Maryrose Morgan.

als (Suckling and Heislers 1978; Menkhorst and Beardsell 1982; Conole and Baverstock 1983; Laidlaw and Wilson 1989; Bennett 1990; Homan 2009). However, these methods have not been successful during surveys for Fat-tailed Dunnart. Morton (1978) failed to trap Fat-tailed Dunnart at three sites in western Victoria and outback New South Wales using these traps, despite the fact that the species was known to occur at each of the study sites at the time of trapping.

Various investigators have tried a variety of traps, but the only methods that have been successful in capturing Fat-tailed Dunnarts have been pitfall traps, active searching and the use of artificial shelters — cage and Elliott traps have not been successful (Menkhorst and Beardsell 1982; Read 1984; Hadden 2002; Clemann *et al.* 2005). Morton (1978) and Parker (2009) have also detected this species while spotlighting. Morton (1978) employed systematic searching under surface rocks at Werribee, Victoria, as his main survey method, resulting in numerous records of Fat-tailed Dunnart. Whilst rock turning is an effective method to detect this species, this technique has resulted in animals being accidentally crushed (Morton 1978).

Other investigators have detected *Sminthopsis* spp. using artificial refuges (Beardsell 1997; Michael *et al.* 2003; Michael *et al.* 2004; Homan 2006; Homan and Schultz 2012; FNCV unpubl. data; G Peterson unpubl. data; P Robertson unpubl.data; D De Angelis unpubl. data). At Challicum, the first record of Fat-tailed Dunnart using a roof tile was obtained in November 2004, five months after the grid was established. Michael *et al.* (2004) suggested that Fat-tailed Dunnart can disperse rapidly and therefore has the ability to quickly colonise artificial refuges. Whilst the number of records from Challicum is fairly small, they provide further evidence that roof tiles and other artificial refuges can provide an efficient and relatively non-intrusive method to survey for the presence of Fat-tailed Dunnart.

Herpetofauna

The Growling Grass Frog is a large, terrestrial hylid frog that historically occurred over a wide area of south-eastern Australia (Cogger 2000; Tyler and Knight 2009). The species was once common throughout much of Victoria; however, in recent times the Growling Grass Frog has disappeared from many parts of its former range (Clemann and Gillespie 2007). Consequently the species is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 and is listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 (DSE 2010). In Victoria, the species is also recognised as vulnerable by the Department of Sustainability and Environment (DSE 2007).

During times of inactivity the Growling Grass Frog shelters in thick vegetation, in cracks in the ground or under refuges such as rocks and logs (Pyke 2002). During the present study two Growling Grass Frogs were found under old fence posts laid beside a restored ephemeral wetland on the floodplain of Fiery Creek. The first specimen was found in mid-April 2011 and the second in mid-September 2011, five

years after the fence posts had been laid at this wetland. Fiery Creek, which flows year round, is situated 150 m to the south of the restored wetland and is likely to be the source of Growling Grass Frogs at this site.

Survey methods for adult Growling Grass Frog include listening for calling males both day and night, active searching at wetlands during the day and detecting adults at night by spotlighting (Heard *et al.* 2006). At Challicum, the species was detected on three other occasions using these methods: adult males were heard calling during the night on two occasions and one adult was seen beside a wetland during the day. The use of artificial refuges offers an additional survey method for Growling Grass Frogs, especially during times of inactivity and at sites where no rocks or natural logs are present.

The Little Whip Snake is a small, nocturnal elapid snake which shelters during the day under rocks or logs, or in cracks in the soil (Cogger 2000; Wilson and Swan 2010). The species is found in woodlands and dry sclerophyll forests and is common in many grassland areas on the Victorian Volcanic Plain (Victorian Biodiversity Atlas). At Challicum, the majority of Little Whip Snake records were from roof tiles, with smaller numbers from galvanised iron and old fence posts. All records were confined to sites with light grazing or no grazing, thick tussock cover and cracking soils. Six were from a site that had been ploughed once many decades previously, whilst 24 were from the unploughed paddock mentioned above. No specimens were found under roof tiles in the three grids established in the area with sparse cover, despite this site having never been ploughed and containing cracking soils. Two other survey methods produced records of Little Whip Snakes at Challicum: pitfall trapping (one capture from 245 pit-nights) and active searching (three specimens found under logs).

Little Whip Snakes have been found at other sites on Victoria's Volcanic Plain with light grazing and substantial grass cover (G Turner pers. comm., 24 February 2007). The species has also been recorded using roof tiles in other parts of the Victorian Volcanic Plain (G Peterson unpubl. data). At QHBP and GFGC Little Whip Snakes readily occupied concrete pavers, with individuals found under a roof tile and galvanised iron. Moderate to thick grass cover and loose surface rock were features of these sites. At these two properties, Little Whip Snakes were recorded by two other survey methods: funnel trapping (one capture from 536 funnel trap-nights at GFGC and one capture from 645 funnel trap-nights at QHBP) and active searching (eight under rocks at GFGC; 10 under rocks and two under logs at QHBP).

Concrete pavers and old fence posts produced the best overall results for herpetofauna, which may in part be due to their insulation properties. Nevertheless, many variables affect data obtained from the use of artificial habitat. Artificial refuges placed on an undulating substrate will produce depressions and cavities that may be attractive to numerous species. Conversely, a large concrete paver placed completely flat on a hard substrate is unlikely to be suitable habitat for most species. However, if a nesting chamber with entrance holes is constructed, this habitat may be used by a range of fauna. Pavers placed on sandy or lose soil may be used by burrowing species such as Bougainville's Skink or Southern Bullfrog. Whilst roof tiles suit small skinks, small frogs and small snakes, like the Little Whip Snake, they are sometimes unsuitable for larger specimens of species such as the Common Blue-tongued Lizard. All specimens of this species found under roof tiles during these studies were juvenile. The condition of old fence posts also affects results. Michael *et al.* (2004) found that several species preferred large, partially decaying posts with many holes. At Challicum, two Little Whip Snakes were found inside cracks in the bottom of older fence posts.

A range of survey methods was used to determine the presence of herpetofauna at each study site. Of the nine reptile and seven amphibian species recorded at the Challicum study sites, using pitfall trapping, funnel trapping, listening, active searching and artificial habitat, seven reptile and five amphibian species were recorded by the use of artificial refuges. Two species, Eastern Brown Snake and Blotched Blue-tongued Lizard, were recorded solely by the use of artificial habitat. Of the 12 reptile and seven amphibian species recorded at QHBP and GFGC, using funnel trapping, listening, active searching and artificial habi-

tat, nine reptile and three amphibian species were recorded by the use of artificial habitat. At QHBP and GFGC, no species were recorded solely by the use of artificial refuges.

Other herpetofauna studies have involved the use of artificial refuges as a survey method, including roof tiles (Clemann and Nelson 2005; O'Shea 2005), concrete pavers (Webb and Shine 2000), galvanised iron (Heinze 1997; Homan 2003) and old fence posts (Michael *et al.* 2003). In western Victoria an extensive study using roof tiles recorded 25 reptile species and seven amphibian species (G Peterson unpubl.data).

Pitfall trapping with drift fence is commonly used to survey small to medium reptiles and terrestrial frogs (Menkhorst 1982; Hadden and Westbrooke 1996; MacNally and Brown 2001; Clemann *et al.* 2005; Thompson *et al.* 2005). However, establishing pitfall lines is labour-intensive and can be extremely difficult in rocky areas or at sites with heavy soils. Digging of pitfall lines in some locations can also cause substantial disturbance to soils and vegetation (pers.obs). Funnel traps have been suggested as an alternative survey method (Thompson and Thompson 2007); however, establishing drift fences for funnel trap lines can also be difficult in rocky areas (pers.obs). The results presented by Brown and Nicholls (1993) suggest that a combination of survey techniques will return the most complete record of reptiles in an area and Mac Nally and Brown (2001) suggest that biodiversity surveys for reptiles may require substantial effort to provide a reasonable representation of the reptile species present in some areas.

Herpetologists have long known that various items of human refuse provide habitat for many reptiles and amphibians (Tyler 2000; Brown *et al.* 2008; Homan 2009; Hoser 2009; Turner 2010). Artificial terrestrial habitat presents an alternative or supplementary method for surveying many species of herpetofauna. Once artificial material is placed on site, checking is relatively easy and safe and poses little risk to specimens sheltering beneath refuges.

Artificial terrestrial habitat as a management tool

Habitat loss, fragmentation and degradation are major causes of decline in populations of vertebrate fauna (Shine 1991; Shine *et al.* 1998; Ford *et al.* 2001; Mac Nally and Brown 2001; Brown *et al.* 2008; Mac Nally *et al.* 2009). Menkhorst (1995) expressed concern for the survival of Fat-tailed Dunnart populations on private land as modern, intensive farming practices cause the loss of shelter and nesting sites. Several studies have highlighted the value of natural terrestrial structures (Halliger 1993; Mac Nally *et al.* 2001; Wallis *et al.* 2007; Alsfeld *et al.* 2009; Heard *et al.* 2010). Revegetation and habitat rehabilitation programs, however, often fail to include, or do not give sufficient importance to the provision of, terrestrial structures such as rocks and logs or artificial alternatives (Buchanan 2009).

In areas where natural refuges have been removed or destroyed, various forms of artificial materials can be used as replacement habitat for some species. In degraded areas devoid of natural terrestrial habitat, the addition of artificial refuges may be beneficial, especially until natural loads accumulate, which may take considerable time (Manning *et al.* 2007).

Various authors have recommended the application of artificial refugia in degraded environments (Goldingay and Newell 2000; Webb and Shine 2000; Lindenmayer *et al.* 2003; Michael *et al.* 2004; Alsfeld *et al.* 2009). Lindenmayer *et al.* (2011) stated that there can be considerable ecological values in adding old fence posts to revegetation areas. Habitat enhancement programs can sometimes be at risk from disturbance from humans (Goldingay and Newell 2000; Webb and Shine 2000). However, Croak *et al.* (2008) demonstrated that colouring artificial refuges, so that they were inconspicuous, was a useful technique to reduce the risk of disturbance.

At Quarry Hills Bushland Park, where a large housing estate borders the reserve, human disturbance was a major management problem. After roof tiles were laid in 2006, many soon became cracked or broken, which may have been due at least partly to human interference. Because of this concrete pavers were introduced as replacements. However, the pavers were unpainted and therefore fairly conspicuous, and when checked in December 2009, 40 were found turned over and not replaced in their

original positions. Challicum and the Growling Frog Golf Course were a considerable distance from towns and housing areas and no human disturbance occurred at these two sites.

Whilst artificial terrestrial refuges can provide important habitat for a wide range of small vertebrates, land managers need to consider several management strategies to ensure that refuges do not suffer from human interference. A combination of camouflaging refuges, fencing or screening with suitable indigenous plants may be necessary to ensure that habitat restoration programs using artificial material are successful.

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A reassessment of the predator responsible for Wakefield's 'Native Cat den' sub-fossil deposits in the Buchan district: Sooty Owl, not Eastern Quoll

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Abstract
Norman Wakefield wrote two papers published in *The Victorian Naturalist* in 1960 that examined four sub-fossil deposits from caves in the Buchan district, East Gippsland, Victoria. Wakefield suggested that Eastern Quolls *Dasyurus viverrinus* were responsible for their accumulation in two caves, M-27 and M-28 (cave tag numbers). There is, however, limited evidence to support Wakefield's conclusion. Instead, there is convincing evidence that the Sooty Owl *Tyto tenebricosa* was responsible. This is based on the structural integrity of the sub-fossil bones, apparent digestive erosion on bones (indicating partial digestion and regurgitation by owls), characteristics of the caves, location of sub-fossils, surrounding habitat, body size-range of mammals within the sub-fossil deposits and known feeding ecology of all owl species. This is an important finding because analysis of the prehistoric and contemporary Sooty Owl diet can provide valuable information for our understanding of the small mammal palaeocommunity, recent declines and mammal conservation. (*The Victorian Naturalist* 129(4) 2012, 138–143)

Keywords: *Tyto tenebricosa, Dasyurus viverrinus*, Norman Wakefield, mammal decline, Gippsland

Introduction

In 1960, Norman Wakefield wrote two articles published in *The Victorian Naturalist*, titled 'Recent mammal bones in the Buchan district – 1' and 'Recent mammal bones in the Buchan district – 2' (Wakefield 1960a, 1960b). Both articles examined mammalian sub-fossil remains excavated from four caves in the Buchan district of East Gippsland; three from the Pyramids area on the Murrindal River (Pyramids Cave (M-89), M-27 and M-28 (cave tag numbers)) and one from East Buchan (Mabel Cave). From the four caves, thousands of remains of small mammals eventually were identified, comprising approximately 44 species (Wakefield 1960a, 1960b, 1967, 1969, 1972). These articles provided significant information regarding the prehistoric distribution of small mammal species during the late Pleistocene and Holocene from south-eastern Australia.

Within the two papers from 1960 some of the material from M-27 and M-28 were only estimates of the number of individual animals found, and some morphologically similar species were not distinguished taxonomically (especially between Agile Antechinus *Antechinus agilis* and White-footed Dunnart *Sminthopsis leucopus*, and between Bush Rat *Rattus fuscipes* and Swamp Rat *Rattus lutreolus*). Although Wakefield conducted further examinations of the Pyramids Cave deposit after the initial 1960 publications, no further work was ever published on the sub-fossil material from M-27 and M-28. Following Wakefield's untimely death in 1972 (Willis 1973), much information about these two deposits was lost. Museum Victoria currently holds considerable material collected by Wakefield from these caves, but the original locality information is suspect for some material labelled as 'M-27 or M-28', 'M-28?', 'Buchan area' or 'Wakefield collection'. So it is difficult to assess whether the museum holds the complete collection. There is also a considerable volume of unsorted and unanalysed postcranial material from both M-27 and M-28. Despite these issues, a comprehensive taxonomic review and quantitative recalculation of the sub-fossil material from M-27 and M-28 would be of considerable value (especially the identification and calculation of the unsorted postcranial material). A reanalysis of the agent responsible for the accumulation of the sub-fossils in the caves also is warranted. This is an important aspect

to understand because sub-fossil deposits are likely to represent a biased representation of the prehistoric mammalian community (Andrews 1990; Baird 1991; Yom-Tov and Wool 1997). If this bias can be better understood, then a more detailed understanding of how and why particular mammal species were present in the deposits can be understood (for example, may explain the absence, low or high representation of some species), thus providing a more comprehensive understanding of the prehistoric mammalian community. Most valuable, however, would be an ability to relate the sub-fossil deposits to the contemporary mammalian community in order to more comprehensively understand change over time and assess the condition of contemporary communities.

Original assessment of how sub-fossils accumulated in M-27 and M-28

Because of tbe position of the caves and the placement of sub-fossils in M-27 and M-28, the only way skeletal remains could accumulate to form large deposits is if they were transported there by a predator (an allochthonous deposit). At the time of Wakefield's publications in 1960, little was known about the feeding ecology of predators potentially responsible for the accumulation of sub-fossils. It was recognised that owls were most likely responsible for accumulating sub-fossil deposits in the Pyramids and Mabel caves because of the presence of numerous intact regurgitated pellets (Wakefield 1960a, 1960b). Wakefield considered that the Masked Owl *Tyto novaehollandiae* was most likely responsible for these two sub-fossil deposits primarily because it is larger than the Eastern Barn Owl *Tyto javanica* and more capable of capturing the larger prey species represented in these deposits (Wakefield 1960b). The relatively similar composition of the sub-fossil deposits within the Pyramids and Mabel caves suggests that the same predator was responsible. However, the composition of the M-27 and M-28 caves was considerably different (although similar to each other), containing much larger and many arboreal mammalian species, indicating that a different predator was likely responsible for these two deposits.

Wakefield considered that 'there is no reasonable doubt that both M-27 and M-28 were dens of the Eastern Native Cat' (currently named Eastern Quoll *Dasyurus viverrinus*) (Wakefield 1960a, p. 166). Wakefield (1960a) supports his claims by stating that quolls accumulate bones in stone shelters and often leave prey uneaten, citing papers by Fleay (1945) and Buckland (1954). The presence of both adult and juvenile Eastern Quoll bones in the deposit were assumed to be those of individuals that died in the deposit (Wakefield 1960a), rather than being prey remains of some other predator. Other terrestrial predators such as Foxes *Vulpes vulpes* and Tiger Cats (Spotted-tailed Quoll *Dasyurus maculatus*) were readily dismissed as likely contributors to the accumulation of sub-fossils, and no other likely predators (or agents) were considered (Wakefield 1960a, 1960b). Such a conclusion appears to have been based on speculation with little supporting evidence, primarily due to the unavailability at the time of ecological information on a range of native predators.

In light of recent ecological knowledge and an examination of remaining sub-fossil material from M-27 and M-28, a more accurate assessment of the predator responsible for these deposits can be made. There are several lines of evidence which suggest that Eastern Quolls were not the predator/agent responsible for the accumulation of sub-fossils in M-27 and M-28, and that a more likely predator was overlooked.

Why quolls were not responsible

Eastern Quolls were widespread and common in south-eastern mainland Australia until the early 1900s, when they underwent a major population crash, and are now extinct on mainland Australia (Menkhorst 1995; Jones 2008). They are now restricted to Tasmania where dietary studies reveal that they predominantly consume invertebrates, small to medium sized vertebrates and plant material (Blackhall 1980; Jones and Barmuta 1998; Jones 2008). Although Eastern Quolls are potentially capable of killing mammalian prey equivalent in size to many individuals in the sub-fossil deposits, they consume mainly small terrestrial vertebrates (Blackhall 1980; Jones and Barmuta 1998). The sub-fossil deposits in M-27 and M-28 contained a high proportion of large individuals (>500 g in body weight) and arboreal

in habit, which is uncharacteristic of typical Eastern Quoll prey. Eastern Quolls would have had great difficulty dragging entire carcasses of prey into M-27 which (at least currently) has a steep rock scree approximately 1 to 1.5 m in height at the entrance of the cave, compounded with having to carry the prey considerable distances to get to the cave. The M-27 cave is also very large, open and spacious (several metres in height and width and extending deep into the cliff), and atypical of Eastern Quoll dens, which are characterised by discreet places that provide considerable shelter, such as small caves, rock piles, logs, stumps, dense vegetation, underground burrows, even under buildings (Godsell 1983; Jones 2008). Eastern Quolls are also scavengers (Jones 2008), so it appears unlikely that hundreds of prey remains would be left uneaten and relatively intact bones left to accumulate.

The home-range of Eastern Quolls is estimated to be typically less than 50 ha (Jones 2008). Therefore, if quolls were responsible for these sub-fossil deposits, their prey must have been captured in close proximity to the cave. Almost immediately in front of both caves (less than 20 m) is an ephemeral river, and immediately behind the cave is a sheer cliff, both of which potentially restrict the amount of habitat and area available for a terrestrial predator to hunt. It is highly unlikely that such a diverse range of prey species as represented within M-27 and M-28 (23-26 non-volant mammalian species) would have been available to Eastern Quolls in such a limited area. Overall, it appears that the predator responsible for these sub-fossil deposits was a much larger, wide ranging species, capable of transporting and consuming a diverse range of mammalian species over 1 kg in weight.

The much larger Spotted-tailed Quoll is capable of killing large and arboreal prey such as the species represented in the sub-fossil deposits (Belcher 1995; Glen and Dickman 2006; Belcher *et al.* 2007). However, there is good evidence that a mammalian predator was not responsible. Mammalian predators such as quolls usually kill their prey, particularly species such as rats, by biting the back of the skull or upper neck (Pellis and Nelson 1984; Pellis and Officer 1987; Jones 1997). Such a fatal bite, combined with subsequent consumption, would result in significant bone breakage and teeth marks on bones, particularly to the skull. At M-27 and M-28, however, reference was made to the large number of entire skulls of rodents, in particular 74 *Rattus* skulls (Wakefield 1960b). The photograph of bones on the floor of M-28 on page 169 (Wakefield 1960a) also highlights a large number of intact/unbroken bones. From recent visits to these sites (by the author), there still remain a significant number of intact/unbroken bones within both M-27 and M-28 caves. Bone material from these caves held at Museum Victoria also contains a large proportion of intact bones, further evidence that these deposits were not created by quolls.

Instead, evidence suggests that the predator/agent responsible for these sub-fossil deposits was not a mammalian predator, and that a more suitable candidate exists. Virtually all aspects of the M-27 and M-28 sub-fossil deposits are characteristic of an owl deposit (e.g. Baird 1991). Owls, particularly members from the genus *Tyto*, regularly ingest and regurgitate entire unbroken bones and intact skulls of their prey (Dodson and Wexler 1979; Kusmer 1990). They commonly roost in caves, and under suitable circumstances bones can accumulate over thousands of years, forming large sub-fossil deposits (Andrews 1990; Baird 1991). Owls are also among the main agents responsible for the accumulation of sub-fossils throughout Australia and the world (e.g. Andrews 1990; Baird 1991). In M-27 and M-28 all the bones are scattered around the floor directly below suitable perching ledges for roosting owls, while in M-27 bones also are located on ledges high above the floor of the cave. The large rocky scree at the entrance of the cave would have reduced accessibility to the caves by terrestrial predators, resulting in a relatively safe secluded position for an owl roosting site. The larger prey species with adult body weight typically exceeding 1 kg, such as Long-nosed Potoroo *Potorous tridactylus*, Eastern (Tasmanian) Bettong *Bettongia gaimardi*, Spotted-tailed Quoll and *Trichosurus* spp. are represented in the deposit mainly as juveniles, again typical of an owl deposit (Baird 1991). However, further evidence that an owl was responsible (at least for the majority of the deposit) from M-27 and M-28 is that numerous postcranial bones

(especially limb bones), particularly of juvenile individuals, have mild digestive erosion on the proximal and distal ends, which indicate that the bones have been ingested and regurgitated, typical of owls (Dodson and Wexler 1979; Kusmer 1990; pers. obs.).

If an owl was responsible, which species?
Historically, at least five, possibly six, species of owl would have occupied the Buchan district. This includes three species of *Ninox*, the Southern Boobook *Ninox novaeseelandiae*, the Powerful Owl *Ninox strenua* and possibly the Barking Owl *Ninox connivens*. These *Ninox* species easily can be eliminated as agents responsible for sub-fossil deposits because they readily break bones of prey, rarely if ever roost in caves (except for the Boobook) and typically consume a wide range of vertebrate and invertebrate prey (e.g. Higgins 1999; pers. obs.). Although Southern Boobook regularly roost in caves, they predominantly consume mammalian prey of less than 100 g, while most of the prey remains in the sub-fossil deposits exceed this weight. On the other hand, the three species of *Tyto*, the Eastern Barn Owl, Masked Owl and Sooty Owl *Tyto tenebricosa* all consume predominantly mammalian prey, regularly roost in caves (or at least did in the past), regurgitate prey remains with limited damage to bones, and are all considered responsible for accumulating sub-fossil deposits elsewhere in Australia (e.g. Baird 1991). There is, therefore, strong evidence that a *Tyto* was responsible for the sub-fossil deposits, and although it is possible that all three species have used the M-27 and M-28 caves at some time over the last few thousand years, one species stands out as the most likely candidate. As each *Tyto* species varies considerably in regard to diet, habitat preference, roosting preferences and body size (e.g. Higgins 1999), a close examination of the composition of the sub-fossil deposits, the position of the cave in the landscape and the surrounding habitat, all help identify a single more suitable candidate.

Between 23 and 26 non-volant mammalian species were represented in the sub-fossil deposits from M-27 and M-28. This is likely to represent most non-volant small mammal species (less than 2 kg in either adult or juvenile body weight) that inhabited the area, except perhaps the Yellow-bellied Glider *Petaurus australis*, Water Rat *Hydromys chrysogaster* and (the large) Red-bellied Pademelon *Thylogale billardierii* (e.g. Menkhorst 1995). The two sites combined contained five arboreal (26%), at least seven scansorial (29%) and 11 terrestrial (45%) species. These species represented a wide range of body sizes, from species under 50 g through to and over 1 kg in adult body weight, most of which were represented by juveniles (Wakefield 1960a).

The smallest *Tyto* species, the Eastern Barn Owl, can easily be eliminated at least from being the major accumulator of the sub-fossil deposits because this owl typically weighs 300-400 g and predominantly consumes terrestrial mammal species of less than 200 g in body weight (Baird 1991; Higgins 1999). The larger Masked Owl weighs up to 900 g and would be capable of consuming the species present in this deposit; however, they also predominantly consume terrestrial species and only occasionally scansorial and arboreal species (Higgins 1999), but these sub-fossil deposits contained a high proportion of arboreal and scansorial prey (56% combined). The upper size limit of prey captured by mainland Masked Owls is poorly understood, but it appears unlikely that they would have consumed such a large proportion of larger prey as represented in the M-27 and M-28 deposits. So although it is possible that the Masked Owl may have been partially responsible for the sub-fossil deposits, a more likely candidate is the Sooty Owl.

Why the Sooty Owl was likely responsible
There is strong evidence to suggest that the predator predominantly responsible for the M-27 and M-28 sub-fossil deposits was the Sooty Owl. The Sooty Owl was dismissed by Wakefield as a possible predator responsible for the Pyramids and Mabel caves sub-fossil deposits only because very little was known about its ecology in the 1960s (Wakefield 1960b). However, knowledge of the ecology and feeding habits of the Sooty Owl has increased considerably since the early 1990s (Debus 1994; Kavanagh 1997; Higgins 1999; Bilney *et al.* 2006; Bilney *et al.* 2010; Bilney *et al.* 2011). The Sooty Owl is not only the largest of the

Tytonidae on the mainland (females regularly weighing up to 1.2 kg) it has also the most generalist diet of any *Tyto* species and is capable of consuming virtually all terrestrial, arboreal and scansorial mammalian species available up to approximately 1.3 kg in size (Kavanagh 1997; Higgins 1999). Such a size range incorporates the prey size of all remains in the M-27 and M-28 caves. Sooty Owls also consume a high proportion of arboreal prey (Bilney *et al.* 2006, 2011a), a feeding trait unlike the other *Tyto* species in the area (Higgins 1999). As the Sooty Owl is a large predator, it rarely consumes small terrestrial prey, and focuses primarily on prey with a body mass in the range of 50 to 900 g (Bilney *et al.* 2011b).

The composition of the sub-fossil deposits from the M-27 and M-28 also closely resembles the composition of sub-fossil deposits in the Mitchell River catchment (about 80 km to the west of Buchan) that are also attributed to the Sooty Owl (see Bilney *et al.* 2010).

Sooty Owls are strongly associated with rainforest and wet forest types in East Gippsland (McIntyre and Henry 2002; Bilney *et al.* 2011) and regularly roost in caves or rock shelters protected under the forest canopy (such as rainforest), usually with an easterly or southerly aspect (Bilney *et al.* 2011). Both the M-27 and M-28 caves are situated under the canopy of Gallery Rainforest, dominated by Kanooka *Tristaniopsis laurina* and Muttonwood *Myrsine howittiana*, face east, and are situated about 20 m from the Murrindal River. All characteristics of the M-27 and M-28 caves are characteristic and suitable Sooty Owl roosting sites.

The importance of identifying a Sooty Owl sub-fossil deposit

Understanding that the sub-fossil deposits from M-27 and M-28 are predominantly prey remains generated by the Sooty Owl can provide important information about the prehistoric mammalian community. As Sooty Owls are capable of overcoming and consuming all mammalian species up to approximately 1.3 kg in weight, this gives confidence that most species that occupied the area surrounding the Pyramids area during the late Holocene are likely to be represented in the deposits. In other words, it is unlikely that there would be many small mammal species that are absent from the deposit.

The other important issue is that because the Sooty Owl is still widespread in East Gippsland, analysis of its contemporary diet can be compared to its prehistoric diet (from the sub-fossil deposits) potentially revealing significant information about the extent of small mammal decline overtime, especially following European settlement (Bilney *et al.* 2010). This technique provides virtually the only ability we have to relate contemporary mammalian community composition to a prehistoric context, therefore potentially providing an assessment of the current condition of mammal communities vital to the understanding of mammal conservation and appropriate land management practices (Bilney *et al.* 2010).

Conclusion

There is strong evidence that the Sooty Owl, rather than the Eastern Quoll (as originally speculated by Wakefield) was responsible for the accumulation of at least the majority of the remains in the sub-fossil deposits excavated from the caves M-27 and M-28. This is potentially an important aspect for future researchers to acknowledge when referring to Wakefield's 1960 papers. The implication that the Sooty Owl was responsible for the accumulation of these sub-fossils has important ramifications for our understanding of small mammal decline and small mammal conservation.

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The Tasmanian records of the Fertile Caladenia *Caladenia prolata* D.L. Jones

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Abstract

In late 1998 the first Tasmanian record of the Fertile Caladenia *Caladenia prolata* D.L. Jones was made in a gully on the western slopes of Strzelecki Peaks in the Strzelecki National Park on Flinders Island. The locality is described below, later searches from 1999 to 2006 are dealt with, an estimate of the number of plants given, and a threat to the major site is discussed. As the taxon is scheduled as 'endangered' under the Tasmanian *Threatened Species Protection Act 1995*, the exact localities are not given here but are detailed on the specimens' labels. (*The Victorian Naturalist* **129** (4), 2012, 144–146)

Key Words: Flinders Island, Fertile Caladenia, *Caladenia prolata*, endangered Tasmanian plant

The discovery in 1998

The western slopes of Strzelecki Peaks have been seriously damaged by bushfires. A gully of the slope still has a dominant layer of White Gums *Eucalyptus viminalis* and Tasmanian Blue Gums *Eucalyptus globulus* subsp. *globulus* but its understorey has, in the main, been replaced by Stinkwood *Zieria arborescens* with a lower layer, often dense, of Tall Cutting-rush *Lepidosperma elatius.* A granite jumble, up to 6 m deep, runs from this gully to just past a tributary gully, not far upstream from their confluence. The jumble, which includes some bedrock at its uphill edge, carries a few remnant rainforest shrubs. There are four Hazel Dogwood *Pomaderris apetala*, one Banyalla *Pittosporum bicolor,* and several Prickly Currant-bush *Coprosma quadrifida.* The jumble supports just one small White Gum. The fringing Blue Gums and White Gums overhang parts of its edge.

In November 1998, some orchids, thought by the length of their leaves when found three months previously to be a Sun-orchid *Thelymitra* sp., were checked in the jumble. The buds showed them to be a *Caladenia* species. Their green colour was novel to the author and five plants, less corms, were posted fresh to David Jones at the Australian National Herbarium in Canberra. He determined them as *Caladenia prolata,* an Australian mainland species not recorded previously in Tasmania.

Twelve of the plants grew on the steep (about 70°) east north-easterly face of a slab 5–6 m above the base of the jumble. They rose from a mat of Common Filmy-fern *Hymenophyllum cupressiforme* (main species) and the ground lichen *Cladia aggregata.* There was one more plant on a level block at the base of the face. The canopy of the one adjacent Hazel Dogwood extended to just past the site. Two lower Prickly Currant-bushes reached to just above the edge of the slab and the block at its base. The nearest other shrub, growing from soil by the edge of the jumble, was a Native Hop *Dodonaea viscosa* var. *spatulata.* The nearby herbs of the jumble included Biserrate Fireweed *Senecio biserratus,* Fireweed *Senecio linearifolius,* Scrub Nettle *Urtica incisa,* Sickle Fern *Pellaea falcata* and Streaked Rock-orchid *Dockrillia striolata* subsp. *striolata.*

Specimen

12.xi.1998, gully of western slopes of Strzelecki Peaks, Flinders Island. John Whinray No. 10601, Australian National Herbarium CANB 669287.

Later records at the initial locality

25 June 1999: 12 leaves on the slab; none on the block at its base.

27 November 1999: 'not a sign of the orchids.'

2 October 2001: six budding plants on the slab.

27 October 2002: eight leaves on the slab and one on the block at its base.

15 October 2005: none under the dense Scrub Nettle on the slab; two leaves on the slab at its base.

5 October 2006: no plants on the slab when the Scrub Nettle was removed; none on the block at its base.

Nearby records

On 5 October 2006, six *Caladenia* plants were found just north of the northwestern corner of the granite jumble. They occurred in 1 m × 3 m of soil that had not been nuzzled by the pigs. The understorey, which started by a seasonal spring just west of the spot, was Rough Tree-fern *Cyathea australis* over Soft Tree-fern *Dicksonia antarctica*. Nearby, in about 20 m by up to 15 m of damp to very wet ground on either side of the spring, were at least 92 *Caladenia* plants, making this the major site. White Gums were the main dominant and a Blue Gum the minor dominant of the locality. There were no shrubs. The first understorey layer was Rough Tree-ferns; there were Soft Tree-ferns below them. Much of the ground was bare of other plants but the orchids extended into Tall Cutting-rush near the head of the spring. The extra plants brought the local total to at least 98.

Two specimens were taken at the major site on 14 November 2006 and forwarded fresh to the Australian National Herbarium. Both were determined as *Caladenia prolata*. Three budding *Caladenia* plants were taken at the same site on 25 November 2006 and, like the prior specimens, were sent to David Jones in Canberra. They were named as one *C. prolata* and two Summer Fingers *C. vulgaris*.

Specimens

14.xi.2006 In a gully of the western slopes of Strzelecki Peaks, Flinders Island. John Whinray No. 12946 *Caladenia prolata*, CANB 740504; same locality, John Whinray No. 12947, *C. prolata*, CANB 740505; 25.xi.2006, same locality, John Whinray No. 12957, one *C. prolata* CANB 780234 and two *C. vulgaris*, CANB 780234.

Other possible records

A single *Caladenia* plant was noticed elsewhere in the jumble but was not sighted again. A group of nine *Caladenia* plants was found on the western edge of the jumble on 24 October 2006. They rose from a mat of the common Filmy-fern near where animals used a track down the patch's eastern edge. An attempt was made to cover the plants by using fallen shrubs but there were few to hand. The partial cover did not stop the animals, which feed by scent at night, from reaching the plants. By 14 November, five leaves remained and some of them had been nibbled. There were no buds. As none has been found flowering, they have not been added to the total. It seems likely, however, that they could include the Fertile Caladenia.

A group of about 40 *Caladenia* plants was found on the crown of a downstream boulder on 12 November 1998. The locality has since been checked more than 15 times. The number of plants surviving by the flowering period each year depends on whether or not the brushtail possums can reach them. The crown was made accessible during this period when a large shrub fell against the boulder. At least 30 leaves were noticed on 25 June 1999 but only 18 remained on 27 November that year. Fifty-nine plants were counted on 5 October 2006 and it seemed that there would be a general flowering. However, only eight had buds by the 24th of that month. Just six plants remained by 14 November. Flowering plants have been found on only two occasions. As all were pink Summer Fingers, they have been excluded from the total given above.

Specimen (of two)

14.xi.2006 On a boulder in a gully of the western slopes of Strzelecki Peaks, Flinders Island. John Whinray No. 12945 *Caladenia vulgaris*, CANB 740503.

Comparison with mainland habitats of the Fertile Caladenia

The Tasmanian rainforest habitat contrasts strongly with that of the Australian mainland. In Victoria the orchid is 'Primarily a plant of near-coastal closed scrublands and open forests, where it grows in sand and clay loams. Also found in woodlands on sandy soils and seasonally inundated, heavy clay loams.' (Backhouse and Jeanes 1995: 96). It is 'Widespread in the wetter districts…' of South Australia and is 'Particularly common in leaf and bark litter under pink gum, cup gum and coastal mallee in scrubs and woodland in a variety of soil types.' (Bates 2011: 13).

Discussion

While the granite jumble was missed by the bushfire of 1960, all the understorey in its vicinity was burnt. The prior major fire on the Strzelecki massif was in c.1939 and lasted for about a month (Athol Dart, pers. comm. March

1965). The absence of rainforest shrubs such as Hazel Dogwood and Musk *Olearia argophylla* from the gully could be the result of fires and the intensive nuzzling by the feral pigs. Nearly all of the accessible ground in the gully, and on the balance of the slopes, has been worked by them repeatedly, to as much as 45 cm deep. Most of the other orchids surviving in soil are at the edges of the track, hardened by thousands of visitors.

Pigs have nuzzled to within a few centimetres of the eastern edge of the major extant occurrence of the Fertile Caladenia. They have yet to work the damp or muddy ground of the spring. There is no apparent reason for their failure to use the western extension of the site, amongst Tall Cutting-rush. There seems to be no cause, except for the repeated nuzzling and the eating of corms, for the Fertile and Common Caladenias to be so restricted in range. Further diminution of their habitat at the major site could be prevented by frequent baiting of a substantial area around it. If carried out consistently this could even allow the orchids to spread slowly in the adjacent soil.

The author has spent some 30 days rambling on the peaks' western slopes without finding any further trace of the Fertile Caladenia and Summer Fingers. Parts of the lower southern slope of the peaks have been worked on several occasions without even one *Caladenia* leaf being noticed. Pink Fingers *C. carnea* were not found higher to the west of the peaks than c. 290 m. The Fertile Caladenia and Summer Fingers were at about 305 m. The main occurrence of the Elegant Caladenia *Caladenia cracens* was on the western side at c. 525 m and just one plant was noticed at 700 m. The Alpine Caladenia *C. alpina* occurred from about 700 m to 782 m on the four peaks and at c. 690 m on the crest just south of them.

Mt Munro is the summit of Cape Barren Island, the second largest island of Banks and eastern Bass Straits. Its summit is 711 m high and Big Hill, the massif's north- western knoll, rises to 490 m. The author has been somewhere on the massif just over 80 times since 1964 without noticing any Caladenias above about 250 m. The plants there, and at c. 225 m, were Green-comb Spider-orchids *C. dilatata.*

The sole record of a Caladenia at a higher elevation on the island is at about 500 m in the upper south-western crevice of Higher Double Peak, the summit of a dissected plateau south-east of Mt Munro. Thirty plants of the Elegant Caladenia *C. cracens* were counted there in late November 2008.

The status of the Fertile Caladenia in Tasmania

The Fertile Caladenia *C. prolata* is scheduled under the Tasmanian *Threatened Species Protection Act 1995* as 'endangered'. The mixed occurrence of Fertile Caladenias and Summer Fingers at the major site of the western slopes of Strzelecki Peaks totalled a little over 100 plants. While the Fertile Caladenia was probably the more common taxon, its scheduling as endangered is thoroughly appropriate.

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Jo Palmer of CANB checked the final mixed collection (No. 12957) and supplied all the accession numbers of the specimens. The bushfire of about 1939 extended to the flats well east of the Strzelecki Peaks and burnt down Athol Dart's family home there. Thelma Shaik of Flinders Island provided many lifts when the author was working the northwestern part of the national park in the late 1990s. The loan of a vehicle by some members of the Loipune Co-operative made the visits of 2006, 2010 and 2011 possible. The many drafts of this contribution were typed on a public computer of the Online Access Centre on Flinders Island.

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The 'Separation Tree': past, present and possible future

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Abstract

An act of vandalism in August 2010 seriously damaged the historically significant native River Red Gum *Eucalyptus camaldulensis*, known as the Separation Tree, located within Melbourne's Royal Botanic Gardens. The vicinity of this tree was one place for the 1850 celebrations of the news that Victoria was to become a separate colony from New South Wales in 1851. The Separation Tree was placed on the Significant Tree Register of the National Trust of Victoria in 1982. In view of the age of the Separation Tree (estimated at about 350 years in 1950), possible future 'replacement' River Red Gum trees were planted nearby in 1951 and 2001, and are growing vigorously. The age of the Separation Tree is currently estimated at about 400 years, although this paper, based on expected diameter growth, suggests that it could be as young as about 260 years. The health of the Separation Tree, according to reports, has waxed and waned up to the present. Despite the ringbarking, this veteran tree currently has a healthy crown and, due to the re-establishment of remnant bark tissue and bridge-grafting, may continue to live for many years yet. (*The Victorian Naturalist* **129** (4), 2012, 147–151)

Keywords: River Red Gum, significant trees, *Eucalyptus camaldulensis*, Royal Botanic Gardens, tree health

Introduction

On 21 August 2010 *The Age* newspaper reported that the old River Red Gum *Eucalyptus camaldulensis* in the Melbourne Royal Botanic Gardens, known as the Separation Tree, had been 'hacked' and 'effectively ring-barked' the previous day, leaving a gash about 1 m wide around its 3.8 m girth and putting the survival of the tree at serious risk.

This article investigates the history and context of this tree and its chances of survival.

Early history

The British Government had granted Victoria separation from New South Wales on 1 August 1850 and the news was published in the Melbourne newspapers on 12 November 1850. That evening a beacon was lit by the Mayor on Flagstaff Hill at 8 pm and there was a 'magnificent' fireworks display (Ridley 1996). Thursday to Saturday (14-16 November) were declared public holidays for the 23 000 citizens of the young Melbourne (Carroll 1972), and on Friday 15 November the new Princes Bridge was officially opened. The formal separation from New South Wales took place later and self-government began in Victoria on 1 July 1851.

At another celebratory event, Neate (1896) records that 'a venerable Gum tree was used as the centre around which the Superintendent of the Province (La Trobe), the officers of the Government and probably many colonists met for the purpose of the celebrations'.

The 1951 brass plaque on the ground near the base of the tree says:

> Under this tree on 15th November 1850 the citizens of Melbourne rejoiced on the receipt of the news that Victoria was to become a separate colony.
> This tablet was unveiled on 15 November 1951 by His Excellency Sir Reginald Dallas Brooks KCB, CMG, DSO, RM, Governor of this State to mark the beginning of the second century of self government in Victoria on 1st July 1951.

Two questions arise: 1. Why was a tree chosen to be a meeting point? 2. Why was that particular tree chosen?

Firstly, according to Carroll (1972), Friday 15 November 1850 was a sunny day and possibly people were looking for a large shady tree under which to 'drink, eat and be merry'. In addition, the newly established lawns around this prominent tree in the recently established Botanic Gardens would have attracted people (National Trust 2011).

Secondly, and most likely, it seems that this large River Red Gum, which later became known as the 'Separation Tree', had significance to the local Aboriginal tribe, and thus already

was a well-known landmark and meeting point (Anon. 1991; Massola 1969).

Context of the Separation Tree

The Separation Tree is located at the north-western corner of the Tennyson Lawn (Back cover).

It is one of two original River Red Gums bordering a swampy billabong (of the Yarra River) which later became part of the existing ornamental lake (National Trust 2011). The second tree, known as the Lion's Head Tree, is of similar size to the Separation Tree, and is about 45 m to the north, close to the edge of the current lake.

About 22 m to the north-east of the Separation Tree, there is another River Red Gum (Fig. 1). The plaque says it was planted on 15 November 1951 by Sir Dallas Brooks—then Governor of Victoria—to eventually replace the Separation Tree when it dies. In October 2011 it was measured to have a girth of 3.05 m and a height of 30 m. Dan Thomas (Curator, Arboriculture, Royal Botanic Gardens) believes that this tree was raised from seed from the Separation Tree (pers. comm. November 2011).

About 11 m south of the 'replacement' River Red Gum, is a sapling raised from a seed from the Separation Tree. This tree was planted by Governor John Landy on 1 July 2001 — the 150th anniversary of the creation of the colony of Victoria. This tree is about 10 m tall and has a girth of 0.44 m at 1.3 m above ground level, and was very healthy in October 2011. Possums have been prevented from eating the crowns of both these trees by plastic cylinders wrapped around the trunk.

Classification as a significant tree

After a report and recommendation by Almond (1982) of the Royal Botanic Gardens, the Separation Tree was classified (A) on 14 January 1982 by the Committee of the Register of Significant Trees of the National Trust of Victoria. It was registered under Category 2 (*any tree which occurs in a unique location or context and so provides a contribution to the landscape, including remnant native vegetation, important landmarks and trees which form part of an historic garden, park or town*) as well as Category 8 (*any tree commemorating or having associations with an important historical event*).

Dimensions and age of the Separation Tree

Table 1 gives key dimensions of the Separation Tree for 1895 and 2003 (from the National Trust database as searched in June 2011), 1982 (Almond 1982), and in 2011 as measured by the author and Dan Thomas.

The 2011 height is an average of two measurements made using a 25 m baseline[1] and a Suunto clinometer. The girth was measured at the standard 1.30 m above ground level,[2] but most bark was missing at this level, so a girth was also recorded at 1.40 m at which level most bark was intact.

In 1982, the age of the tree was estimated at 400 years (National Trust database), indicating an average annual diameter growth of 2.8 mm per year. This value fits in the range of 2.5–6 mm per year, which is given for River Red Gum in the dense Barmah-Millewa forest (Parsons *et al* 1991). However, because the Separation Tree is open-grown and generally healthy, it could be argued that it should have grown at an average of at least 5 mm of diameter per year. If so, this would make the tree only about 260 years old in 2011, 230 in 1982, and thus only about 100 years old in 1850. Note that the nearby tree, planted to eventually 'replace' the Separation Tree, is already a substantial tree although it is only 60 years old, and is growing at an average annual diameter rate of 16 mm per year—typical of a young tree with little competition—

Table 1. Dimensions of the Separation Tree over time. * agl = above ground level

Date	Height (m)	Girth (m) over bark	Crown width (m)
March 1895	20.4	4.7 at 1.0 m agl*	not given
October 1982	22.2	3.5 at 1.4 m agl	not given
June 2003	24.0	3.8 at ? agl	25 (av. in 2 directions)
October 2011	24.4	3.95 at 1.3 m agl 4.10 at 1.4 m agl	23 E-W 21 N-S

Fig. 1. The River Red Gum planted in 1951 as an eventual replacement for the Separation Tree, as viewed from the east (October 2011). The Separation Tree is in the background on the left.

although no doubt assisted by regular watering in dry years.

Not surprisingly for its age, the Separation Tree has grown little in height. The measurements in Table 1 indicate a mere 4 m of growth in 116 years! Crown width has apparently reduced from about 25 m in 2003 to about 22 m in 2011 — but this anomaly may be an artefact of the measurement methods used.

Health of the tree

Over the many years since 1850, the health of the Separation Tree has varied between close to death and flourishing. As a species, *E. camaldulensis* is known to be a tough tree, which hangs on, even through long, hot and dry conditions (Jacobs 1955).

Pitcher (1910:166) records that the Separation Tree had

> on many occasions appeared to be dying, but by various treatments—sometimes by surface soakage and other times by drainage— it has been kept alive, and is today more vigorous than on many occasions during the writer's long and respectful observation of it.

The black and white photo in Pitcher's article (taken south-west of the tree) shows a fairly vigorous crown, and what appears to be ivy around its lower trunk. Compared with 2011, it is clear that at least four lower branches have been cut off since 1910.

In October 1982, Chinner (1982:2) recorded that he 'found the crown to be lacking in evidence of vigour … the foliage was sparse and apparently attacked by lerps and leaf-eating insects.' In 1982, Victoria was in the grip of a severe drought, and a sparse crown was not to be unexpected. However, four years later, Hawker (1987) reported that the tree was in good condition and showed moderate vigour, which he attributed to the wet spring and mild weather of late 1986. He recommended that all dead wood and branch stubs be removed and that any cavities be filled with polyurethane filler.

Width of bark removed in the 2010 ring-barking varied between about 400 and 900 mm (Fig. 2) and about 99% of the circumference was affected. However, when I inspected the tree in January, June, and October 2011, the crown was very green and healthy. In March 2012 it still showed no sign of dieback, 19 months after the ringbarking was carried out. Although most phloem (inner bark) had been removed, there would be xylem (outer wood) still present to conduct water and dissolved salts from the soil up to the tree crown (Hadlington and Johnston 1979). The trunk has a major hollow at a height of about 8 m, probably indicating that the interior of the lower trunk has been consumed by fungi and insects to ground level, but this should not have any major effect on the vigour of the tree.

Soon after the vandalism, pieces of the detached bark were strapped on to the tree in the hope that some of the bark would re-attach itself (Molloy 2012), and black fabric was fixed over the wound area. This treatment was unsuccessful. The tree was surrounded by protective steel temporary fencing as well. A sign says that soil moisture is being monitored at various depths to 70 cm using a solar-powered system. Should the soil measurements drop to below a

Fig. 2. The author next to the Separation Tree, showing the ring-barking and the temporary fence (October 2011).

pre-determined moisture point there is a default irrigation setting, although this can be increased manually (Dan Thomas, pers. comm.)

By June 2011, the black fabric and steel fence had been removed, and a lower fence of strong plastic sheeting has since been erected. By October 2011, three narrow strips of undamaged inner bark on the western side were clearly expanding and conducting food material from the tree crown to the root system. If these continue to grow, the tree could survive its major setback. With ring-barked Silvertop Ash *E. sieberi* in East Gippsland, I have noted that only one narrow strip of outer bark left was enough to keep the tree alive — at least for a few years.

Recently, two types of grafting, using seedlings grown from seed from the Separation Tree, have been attempted, to increase the amount of conducting tissue (Molloy 2012). Firstly, sections of three stems have been 'bridge-grafted' (as described by Hadlington and Johnston 1979) between the upper and lower live tissue on the western side of the tree. Secondly, four

Fig. 3. Two of the four River Red Gum seedlings planted next to the Separation Tree, for future 'approach' grafting over the wound (October 2011).

seedlings were planted in pots on the eastern side of the tree (Fig. 3), and, later, their stems were 'approach-grafted' to live tissue below and above the ring-barking. Time will tell whether these techniques will work.

Conclusion

The historical and cultural significance of the Separation Tree in Melbourne's Royal Botanic Gardens makes it highly valued. Nineteen months after the ring-barking vandalism, the crown of the tree remains very healthy, indicating that its xylem tissue was largely undamaged by the vandalism. Fortunately, remnant live bark strips are expanding and additional grafted tissue (if successful) may be enough to keep the tree alive for many more years.

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Notes

1. Measurements were taken at 25 m from the point directly below the highest point of the tree in two directions from the tree — 30 deg and 215 deg.
2. Girth was measured by wrapping the tape around the circumference of the tree, starting at exactly 1.3 m above upper ground level, and locating the tape at right-angles to any lean of the tree.

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One hundred and two years ago

VICTORIAN VEGETATION IN THE MELBOURNE BOTANIC GARDENS

BY F. PITCHER

Another example of the original vegetation on the Gardens site, is the old gnarled and grey-stemmed specimen of the same eucalyptus, *E. rostrata*, situated a little easterly from the newly erected tea kiosk on the southern edge of the Tennyson Lawn. This specimen, which is. known as the "Separation Tree" had, during the late Director's term of office, on many occasions appeared to be dying, but by various treatments—sometimes by surface soakage and other times by drainage—has been kept alive, and is to-day more vigorous than on many occasions during the writer's long and respectful observation of it. It is hoped that this specimen will be cherished and maintained as long as possible, and be remembered as having been an old tree when, on 1st July, 1851, there assembled at its base and under its foliage a company of people to celebrate the separation of our present State of Victoria from the mother State of New SouthWales.

From *The Victorian Naturalist* **XXVI**, p. 166, March 10, 1910

Confirmed records of the endangered Trout Cod *Maccullochella macquariensis* from the Murray River at Gunbower Island, Victoria

Introduction

The historical range of Trout Cod *Maccullochella macquariensis* (Cuvier, 1829) is thought to have included much of the southern Murray–Darling Basin (Lintermans 2007; Trueman 2007). Severe reductions in both abundance and distribution have led to the conservation status of the species being listed as 'Endangered' (*Environment Protection and Biodiversity Conservation Act* 1999; *Flora and Fauna Guarantee Act* 1988). By the 1980s Trout Cod was restricted to only one, viable, naturally occurring population, located in the Murray River between Yarrawonga and Tocumwal (Berra 1974; Cadwallader *et al.* 1984; Ingram *et al.* 1990). The present distribution of this Trout Cod population is now reported to have increased and includes the Murray River (and anabranches) from Yarrawonga to around Barmah (TCRT 2008; Lintermans 2007) (Fig. 1).

This note presents information indicating the contemporary distribution of the Murray River Trout Cod now extends in the Murray River at least to Cohuna. This extension may raise implications for future Trout Cod management.

Chronology of Trout Cod range extension in the Murray River

In April 2009, the authors angled four juvenile Trout Cod (180–200 mm total length) from the Murray River near Whistler Track on Gunbower Island near Cohuna, Victoria. More Trout Cod were angled by the authors from the same area in April 2010. These confirmed captures indicate Trout Cod are now present in the Murray River in the Gunbower Island area.

Recreational anglers have also reported Trout Cod from the area and these unconfirmed reports appear to be increasing. Anglers have reported captures at Gunbower Island to the local Cohuna tackle store and on angler internet

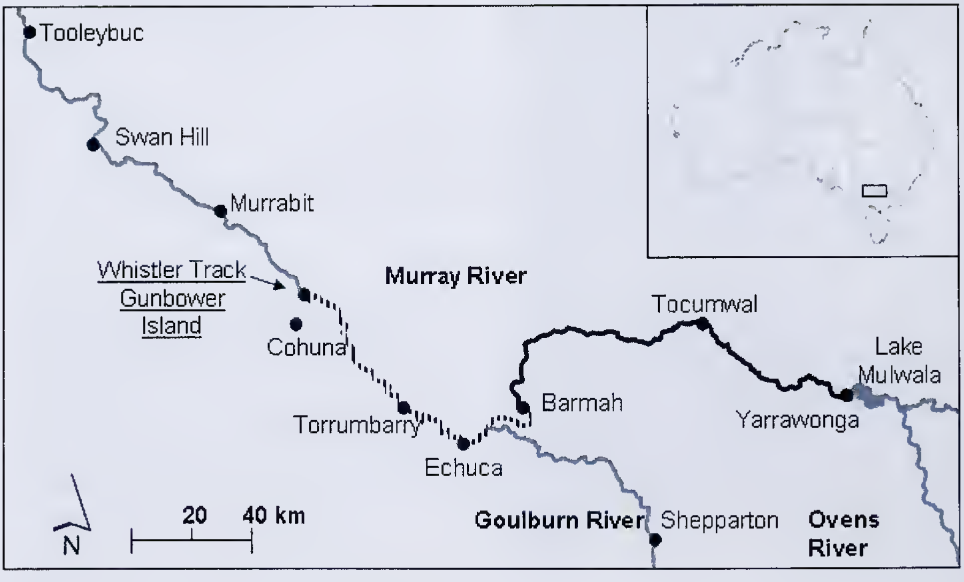

Fig. 1. Distribution of the Trout Cod population in the Murray River, south-east Australia. Bold line indicates published Trout Cod distribution in the Murray River as reported in Lintermans (2007); hashed line indicates the contemporary range extension presented in this study.

forums (Fishnet and Fishvictoria). Additional anecdotal reports from anglers familiar with the species have also been received concerning one fish near Murrabit in 2007, two fish from Swan Hill in 2007 and one fish near Tooleybuc in 2008.

Indication of an extension in the contemporary distribution of the Murray River Trout Cod population has been building for some time. Prior to 2007, isolated reports from downstream of the Tocumwal area were occasionally received. For example, an unconfirmed Trout Cod was taken by a commercial fisherman near Barmah in 1983. But the initial extension in the contemporary distribution of the Murray River population was published only in 1993, when a single fish was collected from an anabranch of the Murray River in Barmah Forest (McKinnon 1993). This was followed shortly afterwards by anecdotal angler reports of juveniles being taken in the area. By about 2005, confirmed adult and juvenile Trout Cod were regularly sampled in the Murray River near Barmah (Victorian Department of Primary Industries unpubl. data) and the collection of Trout Cod larvae by King *et al.* (2009) indicates that Trout Cod breeding was occurring in the Barmah–Millewa area. Unconfirmed reports of Trout Cod captures between Barmah and Echuca were received from recreational angler creel surveys conducted by the Victorian Department of Primary Industries in late 2008 (Brown 2009). Fish movement through the Torrumbarry Weir fishway is monitored by Goulburn Murray staff and the weir keepers recall seeing at least one Trout Cod in the fishway (Terrence W Holt, Senior Reservoir Controller, Torrumbarry Weir, pers. comm., 3 October 2009).

Discussion

The captures of confirmed Trout Cod from the Murray River near Cohuna confirm an extension in the contemporary distribution of the Trout Cod in the Murray River population. This extension is a positive development in Trout Cod conservation and should encourage conservation efforts as applied to the Murray River population.

A key question regarding the presence of Trout Cod in the Murray River at Gunbower Island is the source of the fish and whether the fish are wild or derived from hatchery stockings. We argue that the Trout Cod in the Murray River near Gunbower Island are most likely to be the result of range extension in the wild population rather than migration from hatchery produced stocked fish.

Fish production techniques for a range of native freshwater species—including Trout Cod—have been developed and refined by both NSW and Victorian fisheries agencies to the stage where they are now routine (Ingram *et al.* 1999a; Ingram *et al.* 1999b; Ingram *et al.* 1992). This has allowed restocking programs to be undertaken in an attempt to re-establish viable Trout Cod populations in the Murray–Darling Basin (Ingram *et al.* 2008). Stocking activities have reintroduced nearly one million Trout Cod into eight river catchments across the Murray–Darling Basin (Ingram *et al.* 2008). Evidence of natural recruitment from the stocked fish has been confirmed in four rivers and is suspected in another three rivers (Ingram *et al.* 2008). Despite the limited success of the Trout Cod breeding and stocking programs, the stocking sites are all a considerable distance from Gunbower Island, and such activities are therefore not considered to be implicated in the extension of the contemporary distribution of the Murray River Trout Cod population presented in this report.

There is evidence that some stocked Trout Cod do move from their original stocking site, but as adult Trout Cod have small home ranges—a few hundred metres (Lintermans 2007)—and the closest Trout Cod stocking locations are hundreds of kilometres away in the Murrumbidgee, Ovens and Goulburn Rivers, migration from these areas is not considered as a likely explanation of Trout Cod at Cohuna.

The Murrumbidgee River is stocked with Trout Cod around Narrandera and NSW Fisheries report the current downstream extent of Trout Cod as Leeton Ski Club (Dean Gilligan, pers. comm.). Leeton Ski Club is estimated to be over 400 km upstream of the Murray River junction near Tooleybuc; therefore, Murrumbidgee River Trout Cod stockings are unlikely to explain the captures at Gunbower Island.

The Ovens River has been stocked with Trout Cod and was formerly considered the upstream limit of the contemporary range in the Murray River (Lintermans 2007). Given that the Ovens River enters Lake Mulwala upstream of Yarrawonga Weir, it is highly unlikely that stocked fish have travelled downstream from their stocking site, through Lake Mulwala, the Yarrawonga and Torrumbarry weirs, to the existing Trout Cod population below Yarrawonga at Gunbower Island.

Trout Cod have been stocked into the Goulburn River upstream of Shepparton and there is evidence of continued occupation and breeding of stocked fish in the river (Koster *et al.* 2004). This is the closest stocked population to Gunbower Island. It is feasible that some of these fish may have travelled downstream to the Murray River and then through Torrumbarry Weir to Gunbower Island. It is possible that some of the Goulburn River fish could have moved downstream into the Murray River and be responsible for some of the Trout Cod captures reported by anglers from the river in the Echuca area.

Given the chronology of reports of Trout Cod numbers increasing downstream in the Murray River from Tocumwal, we consider that it is more likely that the Trout Cod in the Gunbower area represent an extension of the contemporary distribution of the Murray River Trout Cod population—through recruitment and expansion in the natural population—rather than immigration of stocked Trout Cod. However, the fish stocked in the Goulburn River cannot be discounted as the source. Regardless of the source, Trout Cod are now present in the Murray River at Gunbower Island.

We conclude that the Trout Cod distribution in the Murray River has extended past the previously-published limits in Lintermans (2007) and currently extends downstream from Yarrawonga to at least the Murray River contiguous with Gunbower Island. An extension in Trout Cod population distribution in the Murray River has implications for the management of the species, both in terms of regulations and where people expect to find the species.

The current NSW Fisheries recreational angling regulations include a seasonal angling closure downstream from the Yarrawonga Weir to the Newell Highway Bridge at Tocumwal. The regulations may require review as the distribution of Trout Cod along the Murray River extends well beyond this protected area.

A major problem with Trout Cod conservation is the difficulty of distinguishing the species from the closely related Murray Cod *Maccullochella peelii*. Anglers may easily misidentify Trout Cod as Murray Cod because they may not be aware of their presence in the mid-Murray River and therefore do not correctly identify the species. Educational programs may now be required to inform recreational fishers that Trout Cod distribution has extended in the Murray River. A publicity campaign highlighting the extended distribution and how to distinguish Trout Cod from Murray Cod may assist in fisheries compliance issues and in protecting the endangered Trout Cod in their expanding distribution.

A specific objective of the current national Trout Cod recovery plan is to facilitate continued sustainability of Trout Cod populations. A specific performance criterion for the objective is that the area of occupancy of the natural Murray River population is stable or increasing (TCRT 2008). Evidence of an extension in the distribution of the population would meet this performance criterion and indicate that conservation efforts for the recovery of Trout Cod are being effective.

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One hundred and ten years ago

NATURAL HISTORY NOTE

The hon. secretary read an extract from a letter from Mr. M'Bain, of Point Lonsdale, to Mr. S. A. Le Souef with reference to the spawning of the Murray Cod, *Oligorus macquariensis*, in which the writer gave it as his experience that the fish spawns about November, when the river, owing to the melting of the snow, is at its highest, and spreads over the flats along its banks, sometimes for miles. Though he had not seen the ova he believes the fish spawn in hollow burnt logs on the flats, where the water is warm, having frequently disturbed the fish in such places, and afterwards seen young fry not more than a quarter of an inch long swimming about in the holes. Directly the water commences to recede the young fry depart and are next found in the main streams in places where there are eddies, and the banks fringed with weeds and long, thin grass; here they are about an inch long, and if not disturbed will remain in the locality until the next season, when they will be about 4 inches in length.

From *The Victorian Naturalist* **XIX**, p. 83, October 9, 1902